Technical Memorandum

October 10, 2002

To: File

From: William B. Kuykendal

Subject: Decisions on Final AP-42 Section 13.2.1 "Paved Roads"

In October 2001, EPA published a draft Section 13.2.1 "Paved Roads" for AP-42 and requested comments. This memorandum summarizes the comments received and presents EPA's decisions and rational supporting these decisions leading to the final section.

Mr. Ronald Myers submitted comments dealing with the moisture correction term. Mr. Myers selected 12 cities representing various climate regions from the *Solar and Meteorological Surface Observation Network 1961 - 1990* CD-ROM. He used precipitation data from these cities to evaluate the comparability of the two options presented in the draft section. His analysis showed that the Daily Option (Option 1) produced an emission reduction factor that was twice the value produced by the Hourly Option (Option 2). EPA agrees that the Daily Option and Hourly Option should produce comparable results. EPA believes that the Hourly Option should be more precise. Therefore, EPA has revised the moisture correction term for the Daily Option to conform with the Hourly Option as follows:

Draft Daily Moisture Correction: (1 - P/2N)

Final Daily Moisture Correction: (1 - P/4N)

Where:

P = number of days with at least 0.254 mm (0.01 in) of precipitation during the averaging period

N = number of days in the averaging period

Mr. Myers also suggested that EPA include both moisture correction options in the final AP-42 section and let the user choose which one to use. There is also good justification for retaining the hourly equation from the perspective of emissions and air quality modeling. In the modeling applications, hourly temporal resolution can be important. Therefore, EPA will publish both options in the final section.

Mr. Myers also presented a rationale that would account for the effect of precipitation reducing silt concentration by washing the road surface. Additionally, he considered the effect of residual moisture after the precipitation event having a mitigative effect. He included an analysis of a hypothetical situation believed to be typical that showed a 20% residual effect of moisture for the Hourly Option. Dr. Richard Countess (see following) also commented that the moisture

correction should have provision for the mitigative effect lasting beyond the precipitation event. Based on these comments, EPA has accepted Mr. Myers' analysis and increased the hourly moisture correction term by 20% as follows:

Draft Hourly Moisture Correction: (1 - P/N)

Final Hourly Moisture Correction: (1 - 1.2 P/N)

Where:

P = number of hours with at least 0.254 mm (0.01 in) of precipitation during the averaging period

N = number of hours in the averaging period

Note: In the final hourly moisture correction term, the 1.2 multiplier is applied to account for the residual mitigative effect of moisture. For most applications, this equation will produce satisfactory results. However, if the time interval for which the equation is applied is short, e.g., for one hour or one day, the application of this multiplier makes it possible for the moisture correction term to become negative. This will result in calculated negative emissions which is not realistic. Users should expand the time interval to include sufficient "dry" hours such that negative emissions are not calculated. For the special case where this equation is used to calculate emissions on an hour by hour basis, such as would be done in some emissions modeling situations, the moisture correction term should be modified so that the moisture correction "credit" is applied to the first hours following cessation of precipitation. In this special case, it is suggested that this 20% "credit" be applied on a basis of one hour credit for each hour of precipitation up to a maximum of 12 hours.

Dr. Richard Countess offered several comments regarding moisture correction, the impact of the amount of precipitation, consistency with unpaved roads regarding the effect of moisture and how to account for vehicle weight. Dr. Countess agreed that a moisture correction term is appropriate for paved road emissions. He suggested that EPA make a distinction between rain and snow, stating that snow would form more of a physical barrier to emissions. This is probably true, but EPA is not aware of any data that is available to quantify the additional reduction attributable to snow. We do not believe that we could develop an additional correction term to account for snow, but a reasonable approach would be to assume zero emissions during periods when the road surface is covered with snow. Note, however, that the application of traction materials following a snow event has the effect of significantly increasing silt loading resulting in increased emissions.

Dr. Countess commented that there is a residual effect of moisture that lasts beyond the precipitation event and would result in reduced emissions for some period after precipitation stops. EPA agrees with this concept and has addressed it in the hourly moisture correction term. Dr. Countess further commented that there should be some consideration for the amount of precipitation that occurs during an event and that the EPA proposed correction terms do not take this in to account. Dr. Countess expanded on this point by developing a comparison with the

application rate of chemical dust suppressants on unpaved roads and asserting that there should be some consistency in estimating the influence of moisture in reducing emissions from both paved and unpaved roads. EPA agrees that in concept this is almost certainly the case. However, we have proposed these correction terms with no measured emissions data to quantify the emissions reductions. Our assumption is that when measurable precipitation (greater than 0.01 inches during a period) occurs, that emissions are zero during the precipitation event. Until data are available that will allow us to quantify the effect of the magnitude of precipitation, EPA will limit the correction term to the on/off approach defined by the 0.01 inch trigger.

Dr. Countess commented that the way EPA accounts for vehicle weight is flawed. He advocates for an approach that would estimate emissions by vehicle weight class then add these emissions rather than the EPA approach which uses an average weight for all of the vehicles traveling on a road. The great majority of the test data that EPA uses to develop the emission factor equations come from tests on public roads where it is not possible to control the distribution of vehicles that traverse the tested road segment. Our regression analysis shows vehicle weight to have a high correlation coefficient. Since it is not possible to determine the emissions from each vehicle during a test, we are limited to using the average weight of all of the vehicles for each test.

Ms. Michelle Chang commented that she favored the selection of Option 1 (Daily Moisture Correction) over Option 2 because PM10 increment modeling is based on a 24 hour average. EPA will allow the use of either option in the final version.

Ms. Evelyn Schulze commented that some German work had shown that the proportion of exhaust pipe emissions to other emissions was about 50:50. She suggested that the AP-42 method should account for the difference in the release mechanism between exhaust emissions and other emissions. EPA agrees that this is likely the case. However, we are limited by the constraints of the test data that do not permit the separation of the exhaust component from the total fugitive emissions. EPA's MOBILE6.1 emissions model includes the particulate matter exhaust component. We are evaluating the possibility of using the MOBILE6 capability to address this issue in a future revision.

As the use of MOBILE6.1 increases, users are cautioned to avoid double counting of the PM components calculated by the MOBILE6.1 model. This is particularly important on high traffic density, low silt loading roads where the emissions from the tailpipe can be a significant portion of total roadway emissions.

Based on these comments, EPA is revising AP-42, Section 13.2.1, Paved Roads, by adding two new equations that account for the mitigative effect of precipitation on long term emissions. Equation 2 applies a correction term on a daily basis, Equation 3 on an hourly basis. The equations are:

Daily Basis:

$$E_{ext} = k\,(sL/2)^{0.65}\,(W/3)^{1.5}\,(1-P/4N) \qquad (2)$$

where:

E_{ext} = annual or other long-term average emission factor in the same units as k
k = base emission factor for particle size range and units of interest (see below)
sL = road surface silt loading (grams per square meter) (g/m^2)
W = average weight (tons) of the vehicles traveling the road
P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period
N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly)

Hourly Basis:

$$E_{ext} = k\,(sL/2)^{0.65}\,(W/3)^{1.5}\,(1\text{-}1.2P/N) \qquad (3)$$

where:

E_{ext} = annual or other long-term average emission factor in the same units as k
k = base emission factor for particle size range and units of interest (see below)
sL = road surface silt loading (grams per square meter) (g/m^2)
W = average weight (tons) of the vehicles traveling the road
P = number of hours with at least 0.254 mm (0.01 in) of precipitation during the averaging period
N = number of hours in the averaging period (e.g., 8760 for annual, 2124 for seasonal, 720 for monthly)

Note: In the hourly moisture correction term (1-1.2P/N), the 1.2 multiplier is applied to account for the residual mitigative effect of moisture. For most applications, this equation will produce satisfactory results. However, if the time interval for which the equation is applied is short, e.g., for one hour or one day, the application of this multiplier makes it possible for the moisture correction term to become negative. This will result in calculated negative emissions which is not realistic. Users should expand the time interval to include sufficient "dry" hours such that negative emissions are not calculated. For the special case where this equation is used to calculate emissions on an hour by hour basis, such as would be done in some emissions modeling situations, the moisture correction term should be modified so that the moisture correction "credit" is applied to the first hours following cessation of precipitation. In this special case, it is suggested that this 20% "credit" be applied on a basis of one hour credit for each hour of precipitation up to a maximum of 12 hours.

List of Comments Received:

Note: Interested parties may review the complete comments which are available in pdf format.

Michelle Chang, email dated November 28, 2001

Richard J. Countess, letter dated November 21, 2001

Ronald E. Myers, letter dated November 30, 2001

Evelyn Schultze, email dated November 27, 2001